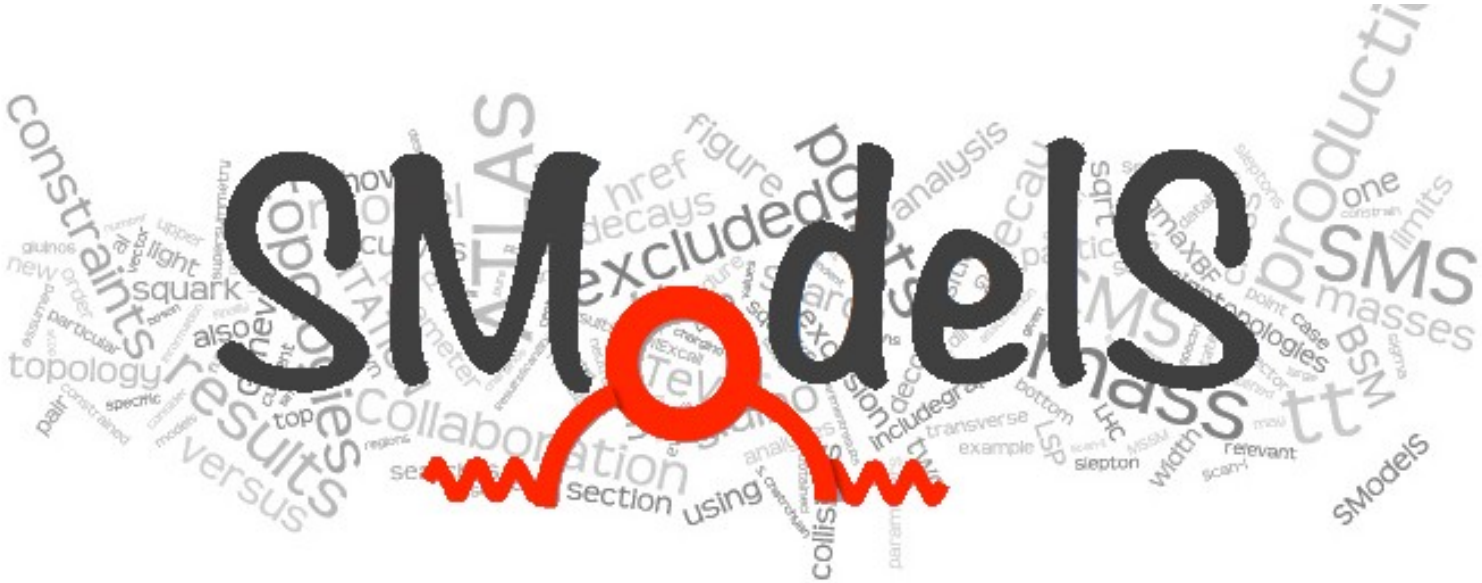
Update on



Wolfgang Waltenberger
HEPHY and Vienna University

for the SModelS group

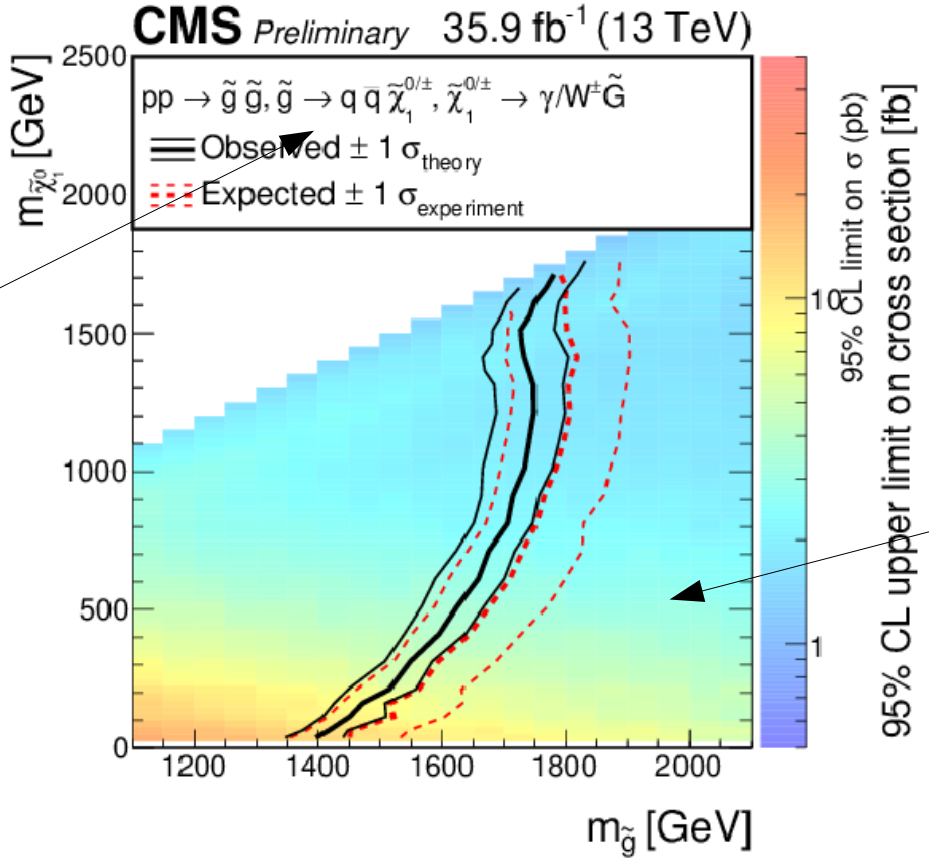
Federico Ambrogi, Juhi Dutta, Jan Heisig, Sabine Kraml, Suchita Kulkarni, Ursula Laa, Andre Lessa, Veronika Magerl, Wolfgang Magerl, Doris Proschofsky, Humberto Reyes-Gonzalez, Jory Sonneveld, Michael Traub, WW, Mathias Wolf, Alicia Wongel <smodels-users@lists.oeaw.ac.at>

Reinterpretation Workshop
Imperial College London, UK, April 2019

Recap: simplified models

Simplified models are models meant to describe physics Beyond the Standard Model (BSM). Contrary to a “full” model like supersymmetry, however, they only introduce a small number (2 or 3) of new particles, allow them to decay only in one specific channel. They are meant as a tool, or a “abstraction interface” for a theorist to the results of the searches of CMS and ATLAS.

the simplified model

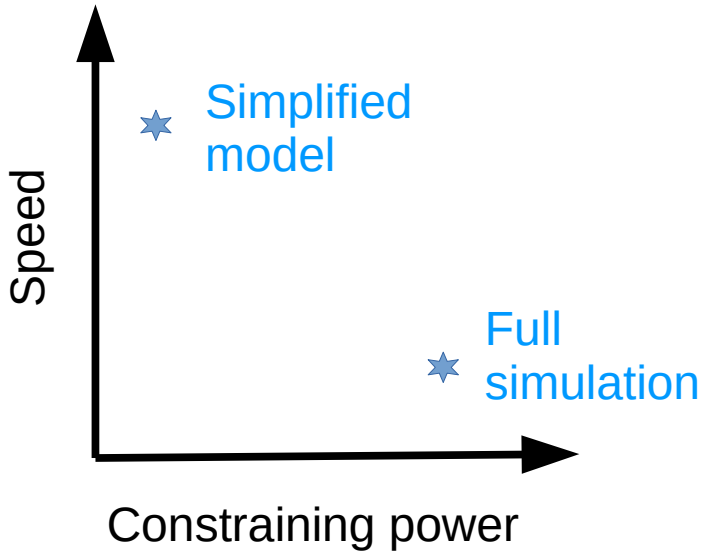


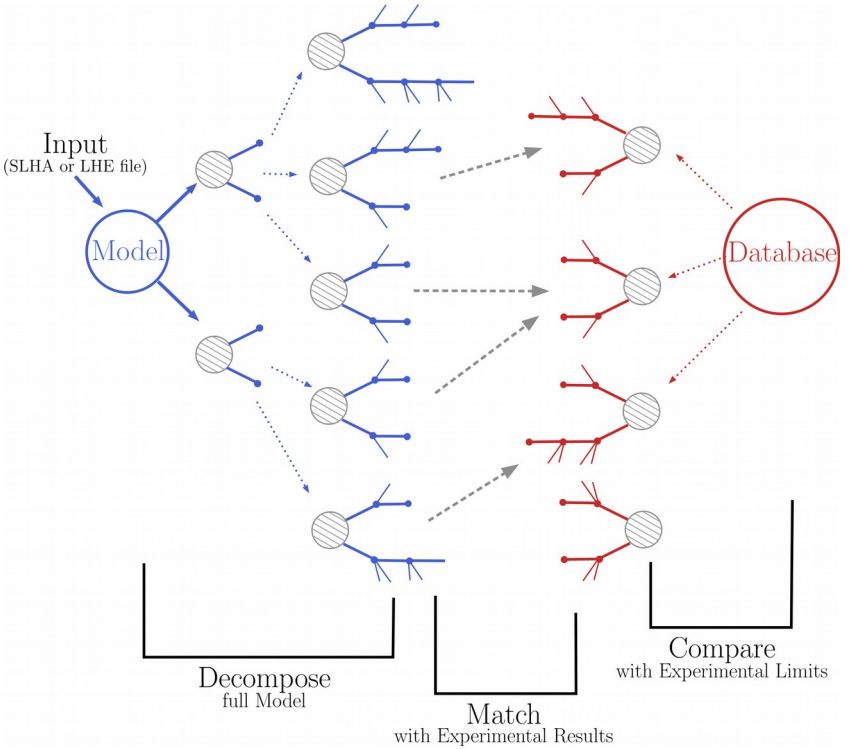
A typical simplified models result, as presented by CMS. Two massive particles ($\tilde{g}$, $\tilde{\chi}$) were introduced. The upper limits on production cross sections (the heatmap) are given as a function of the masses of these two particles.

CMS-PAS-SUS-17-012

Recap: the Idea behind SModelS

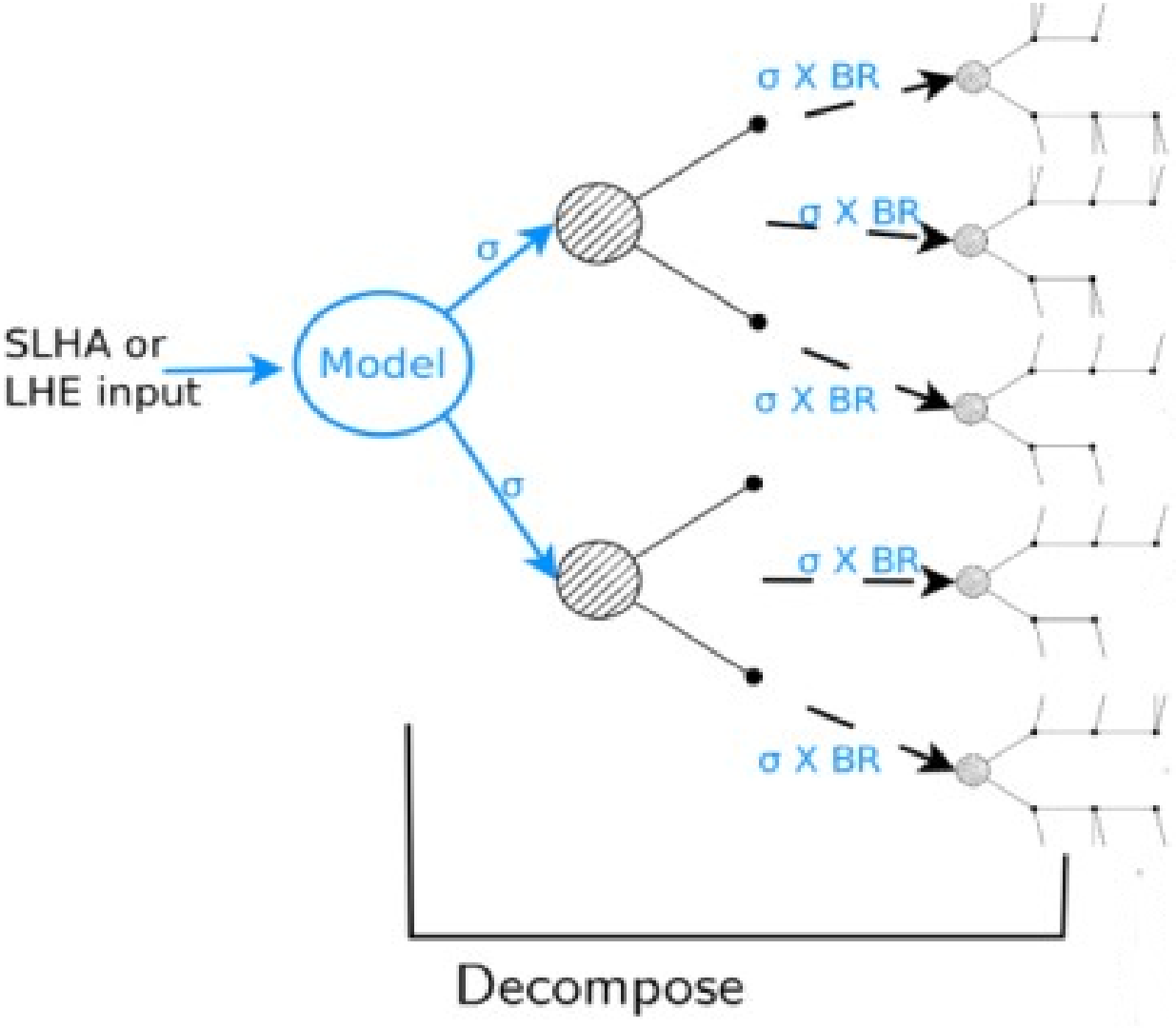
SModelS confronts theories beyond the Standard Model (BSM) with LHC search results by decomposing full models into their simplified models topologies, and comparing the cross section predictions of these individual topologies with a database of SMS results.





Recap: How SModelS works

1) Decomposition of a fundamental model



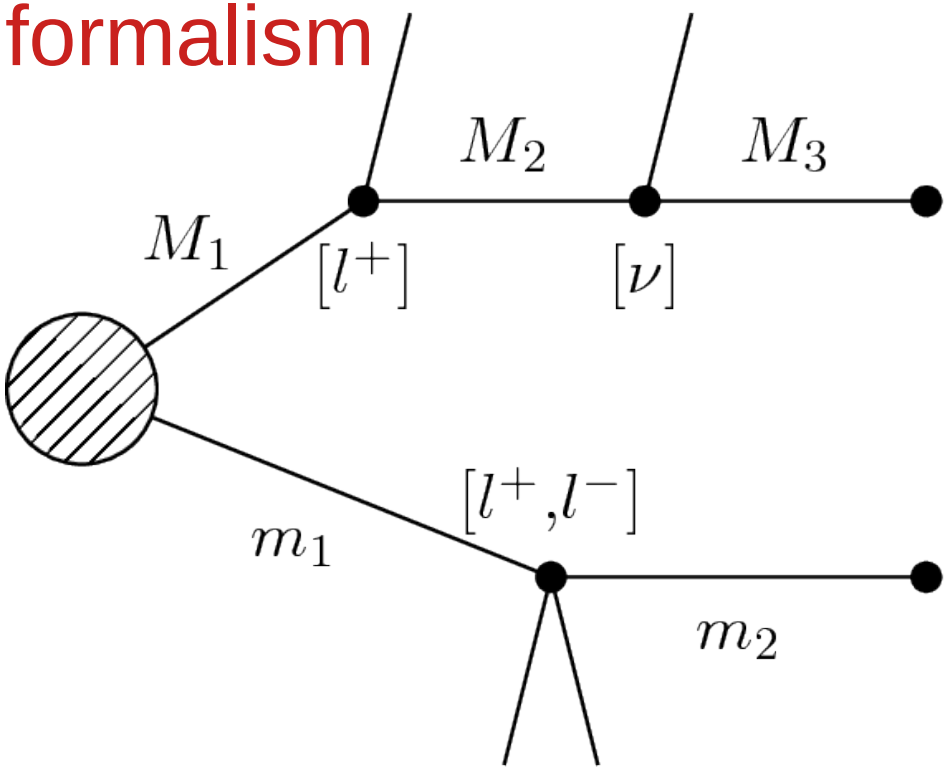
Input: SLHA file (mass spectrum, BRs) or LHE file (parton level)

Currently the model must have a Z_2 symmetry

The decomposition produces a set of simplified model topologies (dubbed “elements”)

Recap: How SModelS works

2) Description of the topology in the SModelS formalism



$= [[l^+],[\nu]]$

$= [\ [[l^+],[\nu]]\ ,\ [[l^+,l^-]]\ ]$

$([[M_1,M_2,M_3],[m_1,m_2]])$

$= [[l^+,l^-]]$

Each topology is described by:

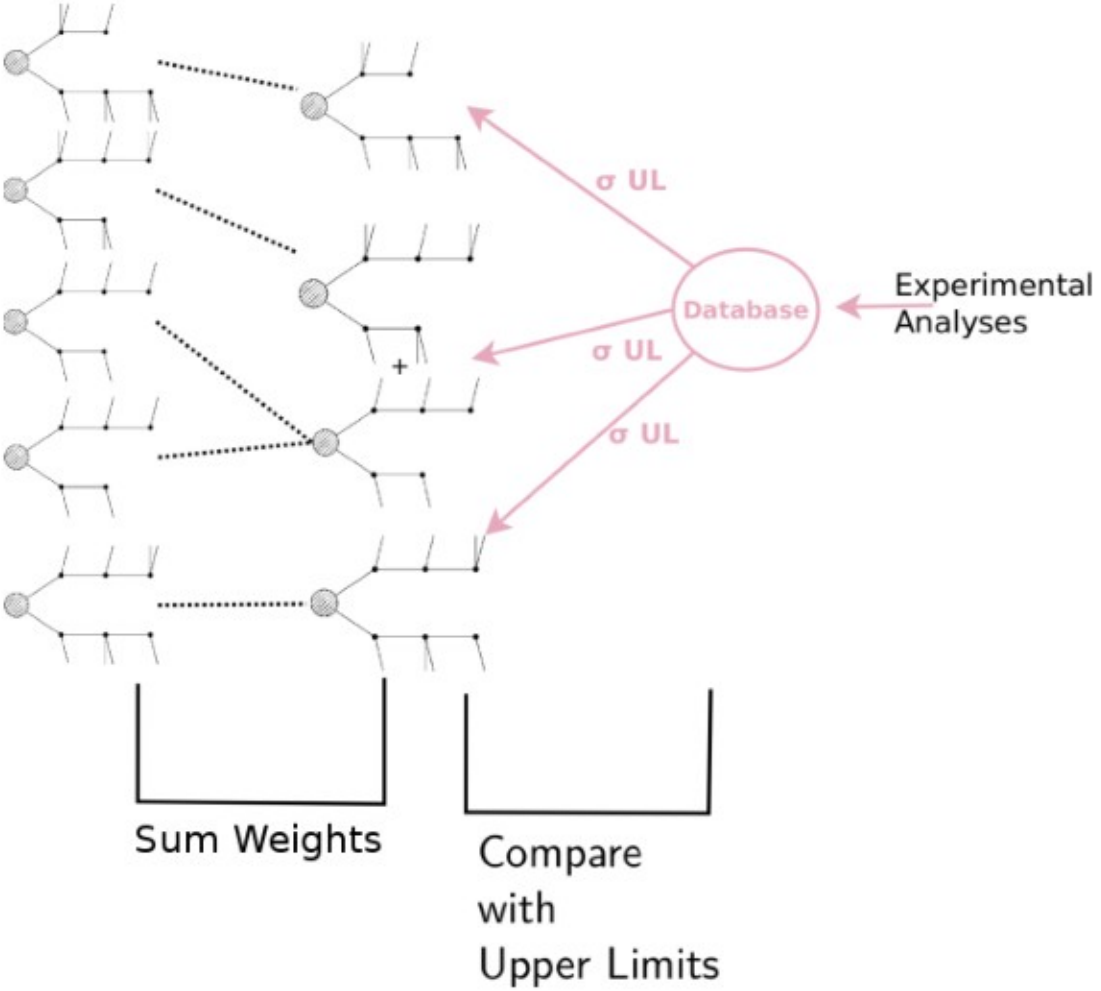
- Topology shape + final states
- BSM masses
- σ x BR

We (currently) ignore spin, color, etc of the BSM particles

It is model independent, there is no reference to the original model

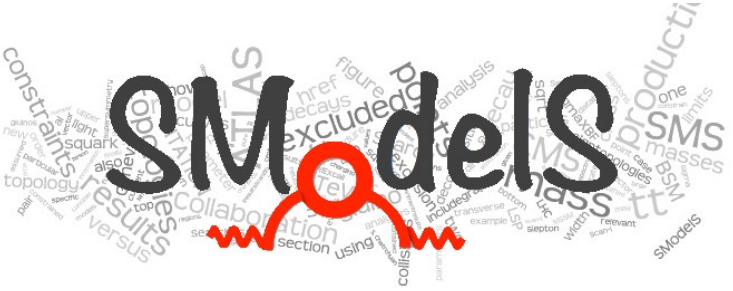
Recap: How SModelS works

3) Comparison of predicted signal strengths with experimental result:



- **Upper Limit Results:**
  Predicted signal strength = σ x BR
  Experimental result: σ_{UL}
- **Efficiency Map Results:**
  Predicted signal strength = ∑ σ x BR x ε
  Experimental result: $\sigma_{UL}=N_{UL}/L$ from $N_{observed}$, expected(BG), error(BG)
- r = predicted / σ_{UL}
- Model is excluded if most constraining analysis has r > 1

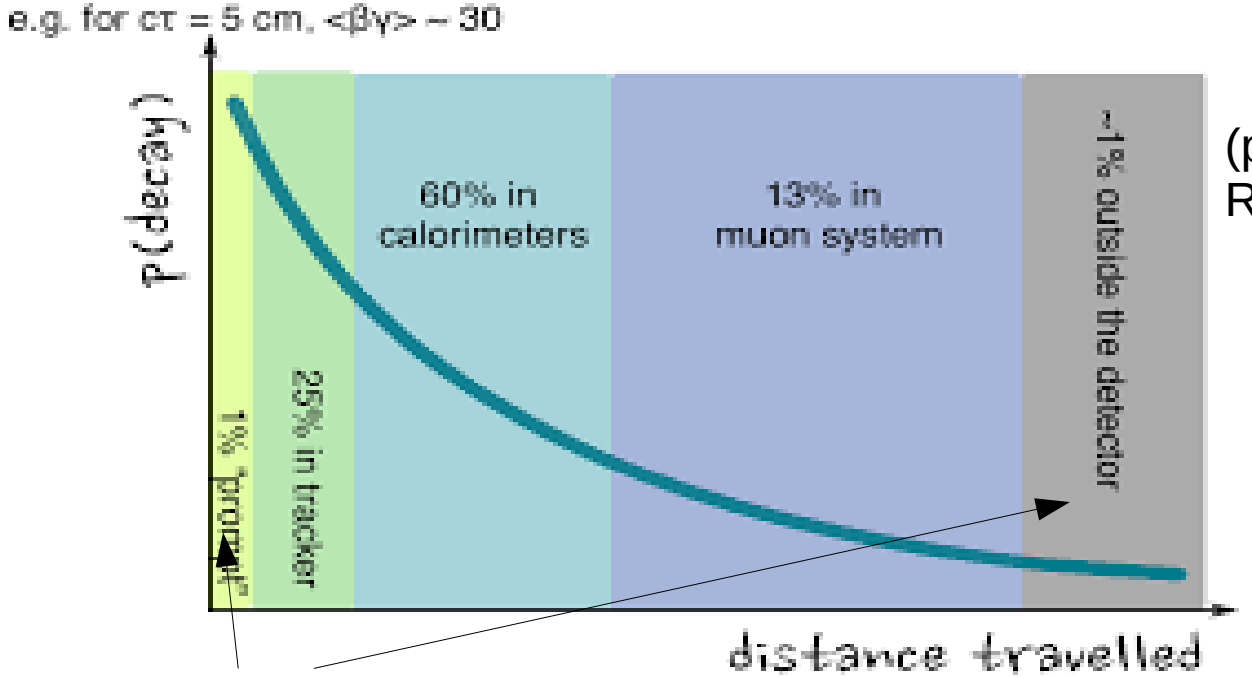
SModelS v1.2.2



Code and database v1.2.2 released end of november 2018. Most important novelties in v1.2.x are:

- Can now deal with Heavy Stable Charged Particles and R-Hadrons (before we could only treat prompt signatures with “missing energy” final states)
- Combination of signal regions exploiting the simplified likelihoods introduced by CMS
- Much larger database of experimental results (almost 100 analyses)

Heavy Stable Charged Particles and R-Hadrons



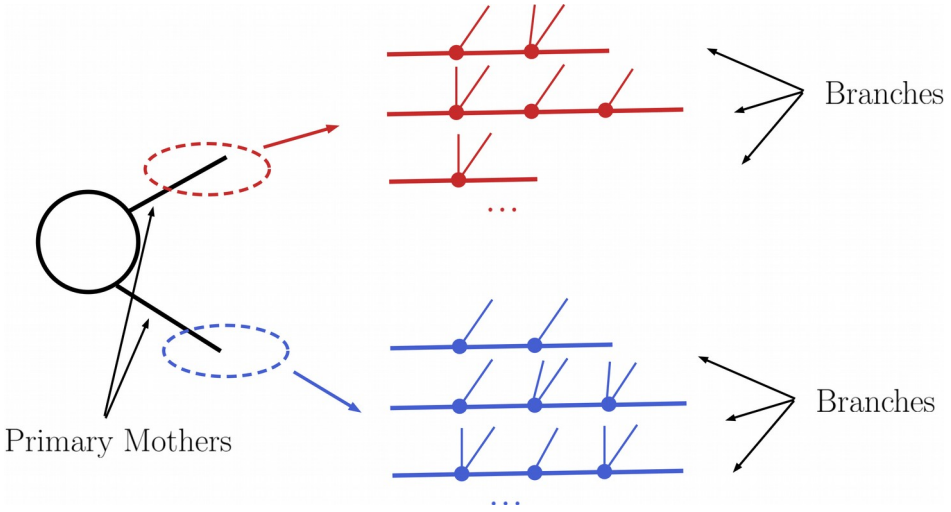
(plot stolen from H. Russell, ATLAS)

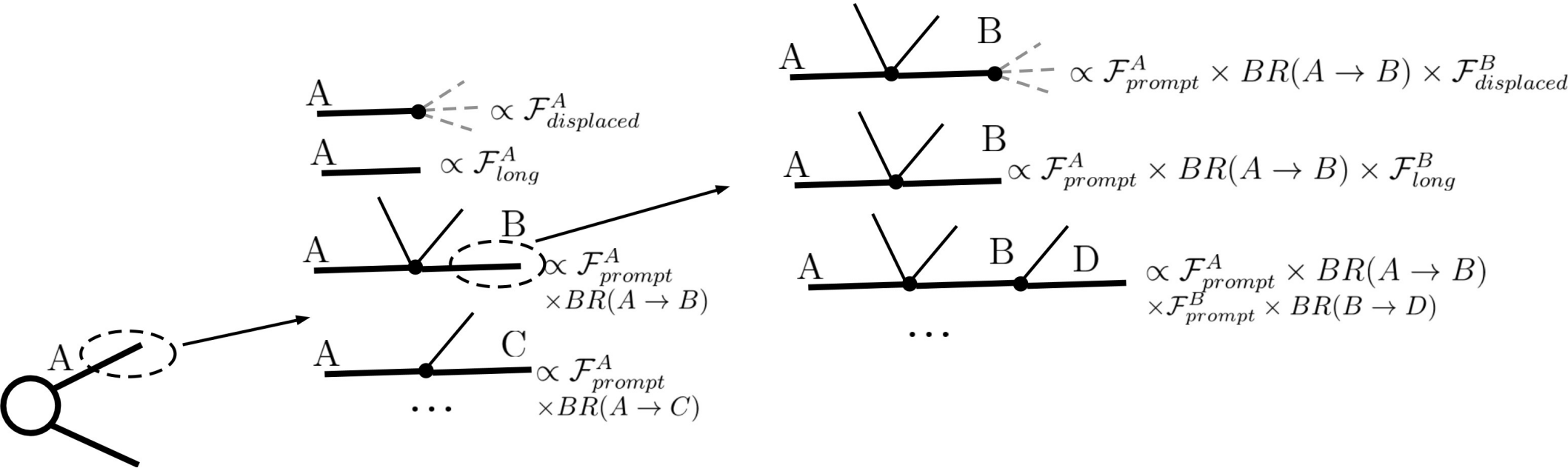
In v1.2.x we make use of the “promp” and “detector stable” fractions of a meta-stable BSM particle, but not displaced signatures.

Starting with v1.2 we make our first moves towards signatures other than missing energy: we can now treat R-Hadrons and Heavy Stable Charged Particles (HSCP), but not yet “displaced” signatures (i.e. BSM particles that decay inside of the detector but outside of the beampipe.

Heavy Stable Charged Particles and R-Hadrons

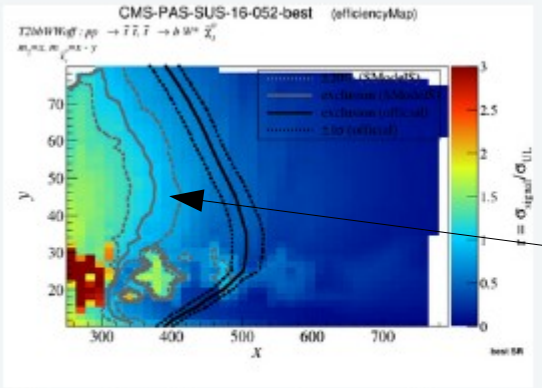
For v.1.2.x we had to extend our decomposition procedure, and compute the fractions of BSM particles that decays promptly, and the detector-stable fractions.



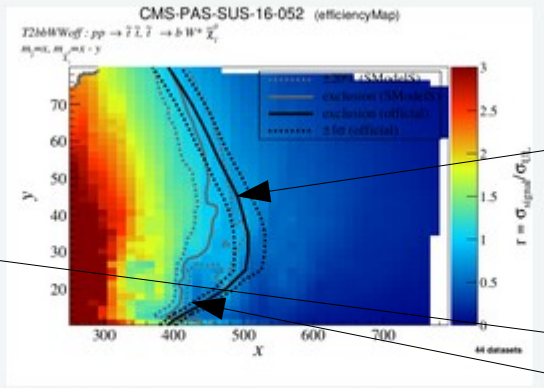


Combination of signal regions

We can now make use of the simplified likelihoods published by the CMS collaboration to combine signal regions into a single joint likelihood for an analysis. Previously we could only make use of the “best” signal region, which is much less constraining.



Best signal region



44 signal regions

dark black line: official CMS exclusion line (everything to its left is excluded)

continuous grey line: our exclusions. for best signal region (left) and combined regions (right)

simplified likelihood v1: the combined likelihood is modeled as multivariate Gaussian for the nuisances and one Poissonian for each signal region. A few CMS analyses published covariance matrices.

$$\mathcal{L}_S(\mu,\boldsymbol{\theta}) = \prod_{i=1}^{N} \frac{(\mu\cdot s_i + b_i + \theta_i)^{n_i} e^{-(\mu\cdot s_i + b_i + \theta_i)}}{n_i!} \cdot \exp\left(-\frac{1}{2}\boldsymbol{\theta}^T \mathbf{V}^{-1}\boldsymbol{\theta}\right)$$

A note on likelihoods

How can we communicate full likelihoods efficiently between experiment and theory?
(The theorists cannot be expected to know too many details about the nuisance parameters.
The experimentalists need to feel comfortable about the information that they hand out.)

By now, we have a few proposals on the table for analyses with multiple signal regions:

Simplified likelihood, v1: All nuisances summarized in a single "all enveloping" multivariate Gaussian that "connects" all signal regions (which are Poissonian counting variables):

$$\mathcal{L}_S(\mu,\boldsymbol{\theta}) = \prod_{i=1}^{N} \frac{(\mu\cdot s_i + b_i + \theta_i)^{n_i} e^{-(\mu\cdot s_i + b_i + \theta_i)}}{n_i!} \cdot \exp\left(-\frac{1}{2}\boldsymbol{\theta}^T \mathbf{V}^{-1}\boldsymbol{\theta}\right)$$

CMS-NOTE-2017-001

Simplified likelihood, v2: a skewness term is added to allow for asymmetrical distributions.

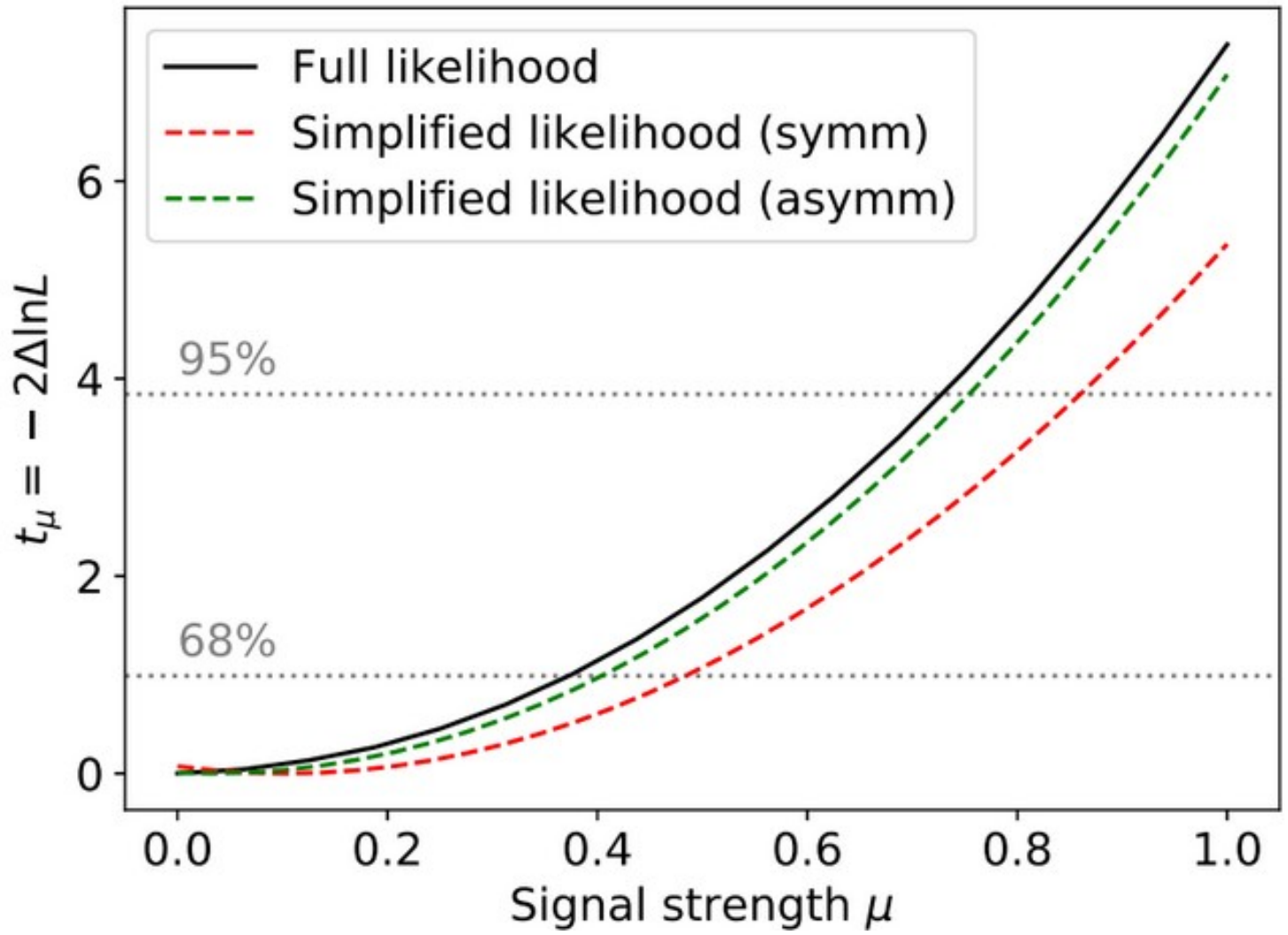
$$L_S(\alpha,\theta) = \prod_{I=1}^{P} \Pr\left(n_I^{\text{obs}} \,\middle|\, n_{s,I}(\alpha) + a_I + b_I\theta_I + c_I\theta_I^2\right) \cdot \frac{e^{-\frac{1}{2}\theta^T \rho^{-1}\theta}}{\sqrt{(2\pi)^P}}$$

to appear as:
JHEP 021P 1018

arXiv:1809.05548

PyHistFactory: the likelihood as a binned histogram, in a JSON (c.f. Lukas Heinrich's talk yesterday and in the last workshop)

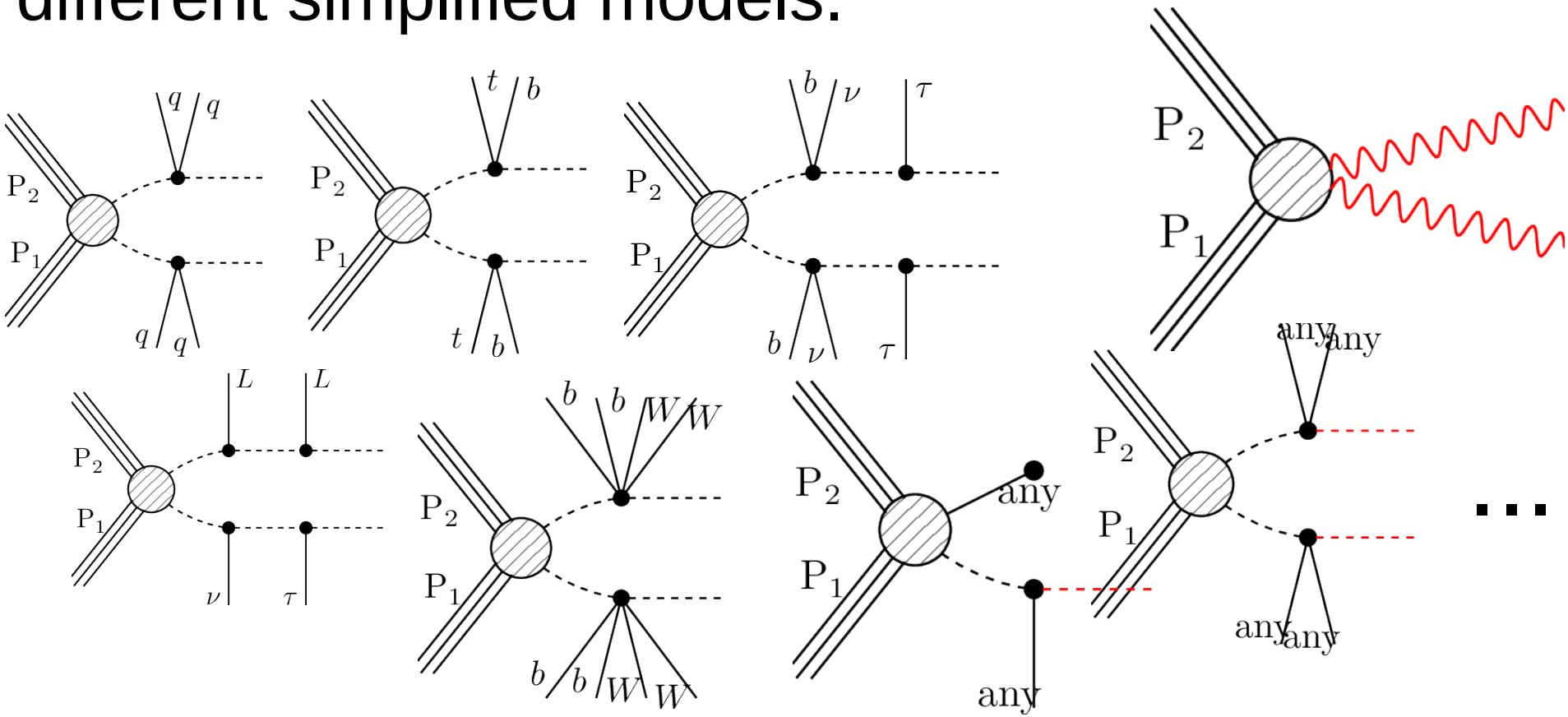
To elaborate a bit on the differences between simplified likelihood v1 and v2, and the full likelihood, here is an example:



Plot taken from: JHEP 021P 1018 (arXiv:1809.05548)

Simplified models

The current database v1.2.2 has results for 76 different simplified models.



Currently, we do not care about the quantum numbers of the BSM particles other than their masses (thats why the BSM particles are unspecified in the graphs above). Currently we are still restricted to models with a Z_2 symmetry.

https://smodels.github.io/docs/SmsDictionary

Simplified models

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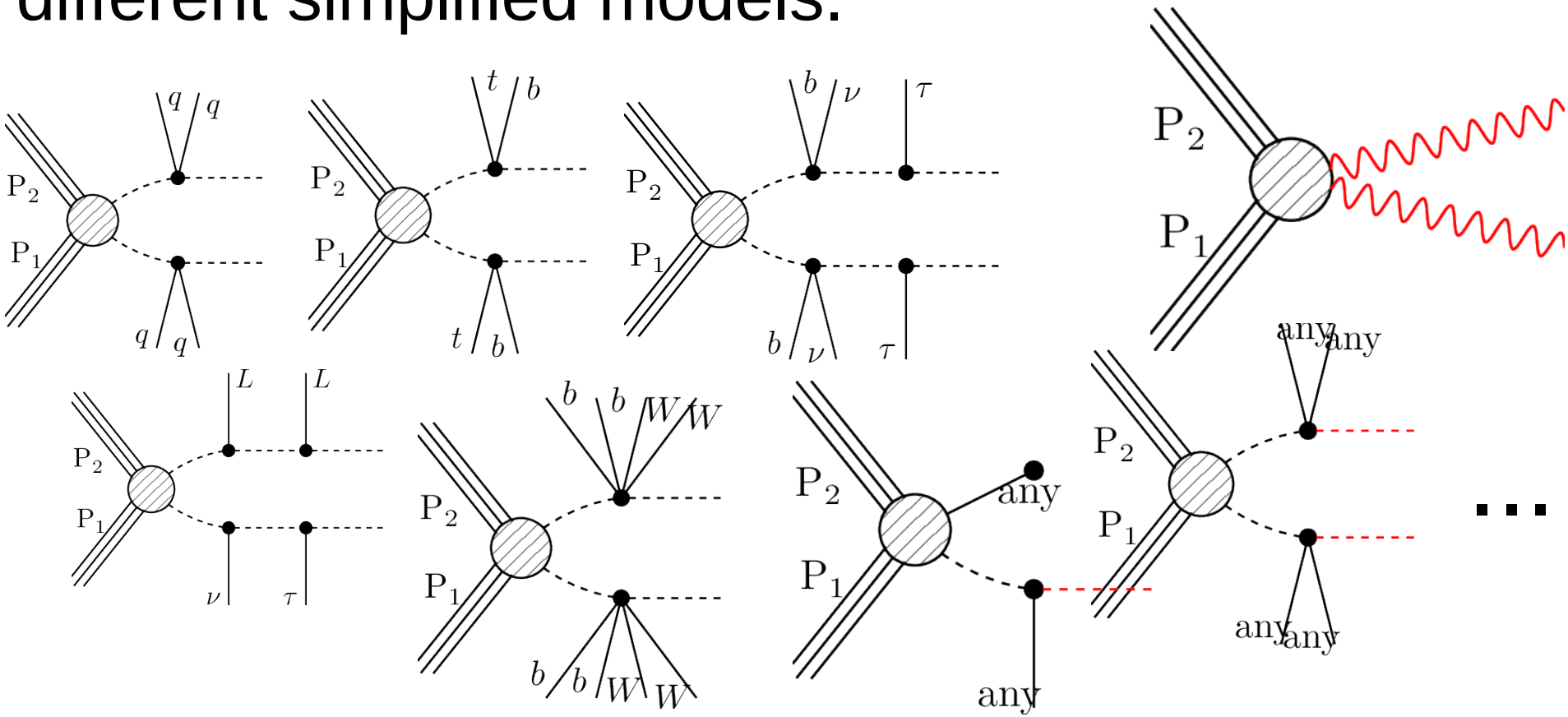

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https://smodels.github.io/docs/SmsDictionary

SModelS database

#	ID	pretty name	Topologies	Type	$\mathcal{L}$ [fb^{-1}]
1	ATLAS-SUSY-2015-01	2 b-jets + $\not{E}_T$	1: T2bb	ul	3.2
2	ATLAS-SUSY-2015-02	single l stop	1: T2tt	ul	3.2
	ATLAS-SUSY-2015-02	single l stop	1: T2tt	eff	3.2
3	ATLAS-SUSY-2015-06	0 l's + 2-6 jets + $\not{E}_T$	2: T1, T2	eff	3.2
4	ATLAS-SUSY-2015-09	jets + 2 SS l's or >=3 l's	1: T1tttt	ul	3.2
5	ATLAS-SUSY-2016-14	2 SS or 3 l's + jets + $\not{E}_T$	3: T1tt[off]tt, T1tttt[off]...	ul	36.1
6	ATLAS-SUSY-2016-17	2 opposite sign l's + $\not{E}_T$	2: T2bbWW[off], T2tt[off]...	ul	36.1
7	ATLAS-SUSY-2016-19	stops to staus	1: T4bmtaubmtau...	ul	36.1
8	ATLAS-SUSY-2016-26	>=2 c jets + $\not{E}_T$	1: T2cc	ul	36.1
9	ATLAS-SUSY-2016-33	2 OSSF l's + $\not{E}_T$	2: T5ZZ, T6ZZ	ul	36.1
10	ATLAS-SUSY-2017-03	multi-l EWK searches	1: TChiWZ	ul	36.1
11	ATLAS-CONF-2012-105	2 SS l's + >= 4 jets + $\not{E}_T$	1: T1tttt	ul	5.8
12	ATLAS-CONF-2012-166	1 l + 4(1 b-)jets + $\not{E}_T$	1: T2tt	ul	13.0
13	ATLAS-CONF-2013-001	0 l's + 2 b-jets + $\not{E}_T$	1: T6bbWW[off]	ul	12.8
14	ATLAS-CONF-2013-007	2 SS l's + 0-3 b-jets + $\not{E}_T$	4: T1btbt, T1tttt...	ul	20.7
15	ATLAS-CONF-2013-024	0 l + 6 (2 b-)jets + $\not{E}_T$	1: T2tt	ul	20.5
	ATLAS-CONF-2013-024	0 l + 6 (2 b-)jets + $\not{E}_T$	21: T1bbbb, T1bbbt...	eff	20.5
16	ATLAS-CONF-2013-025	>= 5 (>=1 b-)jets + 2, 3 SFOS l's + $\not{E}_T$	1: T6ZZtt	ul	20.7
17	ATLAS-CONF-2013-035	3 l's (e,mu) + $\not{E}_T$	2: TChiChipmSlepL...	ul	20.7
18	ATLAS-CONF-2013-037	1 l + >= 4(1 b-)jets + $\not{E}_T$	1: T2tt	ul	20.7
	ATLAS-CONF-2013-037	1 l + >= 4(1 b-)jets + $\not{E}_T$	18: T1bbbb, T1bbbt...	eff	20.7
19	ATLAS-CONF-2013-047	0 l's + 2-6 jets + $\not{E}_T$	3: T1, T5WW[off]...	ul	20.3
	ATLAS-CONF-2013-047	0 l's + 2-6 jets + $\not{E}_T$	24: T1, T1bbbb, T1bbbt...	eff	20.3
20	ATLAS-CONF-2013-048	2 l's + (b-)jets + $\not{E}_T$	2: T2bbWW, T6bbWW[off]...	ul	20.3
	ATLAS-CONF-2013-048	2 l's + (b)jets + $\not{E}_T$	11: T1bbtt, T1btbt...	eff	20.3
21	ATLAS-CONF-2013-049	2 l's (e,mu) + $\not{E}_T$	1: TSlepSlep	ul	20.3
22	ATLAS-CONF-2013-053	0 l's + 2 b-jets + $\not{E}_T$	1: T2bb	ul	20.1
	ATLAS-CONF-2013-053	0 l's + 2 b-jets + $\not{E}_T$	17: T1bbbb, T1bbbt...	eff	20.1
23	ATLAS-CONF-2013-054	0 l's + >= 7-10 jets + $\not{E}_T$	24: T1, T1bbbb, T1bbbt...	eff	20.3
24	ATLAS-CONF-2013-061	jets + >= 3 b-jets + $\not{E}_T$	3: T1bbbb, T1btbt...	ul	20.1
	ATLAS-CONF-2013-061	jets + >= 3 b-jets + $\not{E}_T$	21: T1bbbb, T1bbbt...	eff	20.1
25	ATLAS-CONF-2013-062	1 l + jets + $\not{E}_T$	21: T1, T1bbbb, T1bbbt...	eff	20.3
26	ATLAS-CONF-2013-065	2 l's + (b-)jets + $\not{E}_T$	2: T2tt, T6bbWW	ul	20.3
27	ATLAS-CONF-2013-089	2 l's (e,mu) + $\not{E}_T$	1: T6WW	ul	20.3
28	ATLAS-CONF-2013-093	1 l + 2 b-jets + $\not{E}_T$	1: TChiWH	ul	20.3
	ATLAS-CONF-2013-093	1 l + 2 b-jets + $\not{E}_T$	6: T1bbbt, T2bt, T2tt...	eff	20.3
29	ATLAS-SUSY-2013-02	0 l's + 2-6 jets + $\not{E}_T$	5: T1, T2, T5WW[off]...	ul	20.3
	ATLAS-SUSY-2013-02	jets and met	4: T1, T2, T3GQ, T5...	eff	20.3
30	ATLAS-SUSY-2013-04	0 l's + >= 7-10 jets + $\not{E}_T$	1: T1tttt	ul	20.3
	ATLAS-SUSY-2013-04	0 l's + >= 7-10 jets + $\not{E}_T$	8: T1bbbb, T1btbt...	eff	20.3
31	ATLAS-SUSY-2013-05	0 l's + 2 b-jets + $\not{E}_T$	2: T2bb, T6bbWW[off]...	ul	20.1
	ATLAS-SUSY-2013-05	0 l's + 2 b-jets + $\not{E}_T$	1: T2bb	eff	20.1
32	ATLAS-SUSY-2013-08	Z + b-jets + $\not{E}_T$	1: T6ZZtt	ul	20.3
33	ATLAS-SUSY-2013-09	2 SS l's + $\not{E}_T$	1: T1tttt	ul	20.3
34	ATLAS-SUSY-2013-11	2 l's (e,mu) + $\not{E}_T$	4: TChiWW, TChiWZ...	ul	20.3
	ATLAS-SUSY-2013-11	2 l's (e,mu) + $\not{E}_T$	3: TChiWW[off], TChipChimSlepSnu...	eff	20.3
35	ATLAS-SUSY-2013-12	3 l's (e,mu,tau) + $\not{E}_T$	4: TChiChipmSlepL...	ul	20.3
36	ATLAS-SUSY-2013-15	1 l + 4 (1 b-)jets + $\not{E}_T$	1: T2tt	ul	20.3
	ATLAS-SUSY-2013-15	1 l + 4 (1 b-)jets + $\not{E}_T$	1: T2tt	eff	20.3
37	ATLAS-SUSY-2013-16	0 l + 6 (2 b-)jets + $\not{E}_T$	1: T2tt	ul	20.1
	ATLAS-SUSY-2013-16	0 l + 6 (2 b-)jets + $\not{E}_T$	1: T2tt	eff	20.1
38	ATLAS-SUSY-2013-18	0-1 l's + >= 3 b-jets + $\not{E}_T$	2: T1bbbb, T1tttt...	ul	20.1
	ATLAS-SUSY-2013-18	0-1 l's + >= 3 b-jets + $\not{E}_T$	2: T1bbbb, T1tttt...	eff	20.1
39	ATLAS-SUSY-2013-19	2 OS l's + (b-)jets + $\not{E}_T$	2: T2bbWW, T2tt	ul	20.3
40	ATLAS-SUSY-2013-21	monojet or c-jet + $\not{E}_T$	3: T2bb, T2bbWW[off]...	eff	20.3
41	ATLAS-SUSY-2013-23	1 l + 2 b-jets (or 2 γs) + $\not{E}_T$	1: TChiWH	ul	20.3
42	ATLAS-SUSY-2014-03	>= 2(c-)jets + $\not{E}_T$	1: TScharm	eff	20.3

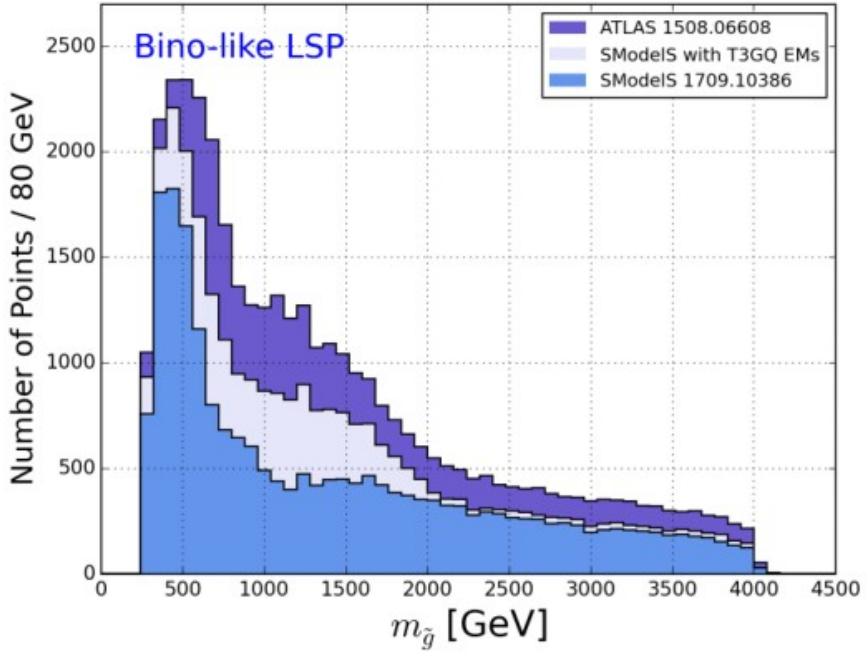
#	ID	pretty name	Topologies	Type	$\mathcal{L}$ [fb^{-1}]	$\sqrt{s}$
1	CMS-PAS-EXO-16-036	hscp search	3: THSCPM1b, TRHadGM1...	ul	12.9	13
	CMS-PAS-EXO-16-036	hscp search	8: THSCPM1b, THSCPM2b...	eff	12.9	13
2	CMS-PAS-SUS-15-002	>= 4jets + $\not{E}_T$, HT, HTmiss	2: T1, T1bbbb	ul	2.2	13
3	CMS-PAS-SUS-16-014	jets + $\not{E}_T$, HT	6: T1, T1bbbb, T1tttt[off]...	ul	12.9	13
4	CMS-PAS-SUS-16-015	jets + $\not{E}_T$, MT2	6: T1, T1bbbb, T1tttt[off]...	ul	12.9	13
5	CMS-PAS-SUS-16-016	>= 1 jet + $\not{E}_T$, α_T	4: T1bbbb, T1tttt[off]...	ul	12.9	13
6	CMS-PAS-SUS-16-019	jets + 1 l	1: T1tttt[off]	ul	12.9	13
7	CMS-PAS-SUS-16-022	>= 3 l's + $\not{E}_T$	1: T1tttt[off]	ul	12.9	13
8	CMS-PAS-SUS-16-052	soft l, <= 2 jets	2: T2bbWW[off], T6bbWW[off]...	ul	35.9	13
9	CMS-PAS-SUS-16-052-agg	soft l, <= 2 jets	2: T2bbWW[off], T6bbWW[off]...	eff	35.9	13
10	CMS-PAS-SUS-17-004	multi-l EWK searches	2: TChiWH, TChiWZ[off]...	ul	35.9	13
11	CMS-SUS-15-002	multijets + $\not{E}_T$, HT	3: T1, T1bbbb, T1tttt[off]...	ul	2.2	13
12	CMS-SUS-15-008	SS dil	1: T1tttt[off]	ul	2.3	13
13	CMS-SUS-16-032	Sbottom and compressed stop	2: T2bb, T2cc	ul	35.9	13
14	CMS-SUS-16-033	0L + jets + $\not{E}_T$	6: T1, T1bbbb, T1tttt[off]...	ul	35.9	13
15	CMS-SUS-16-034	2 OSSF l's	2: T5ZZ, TChiWZ	ul	35.9	13
16	CMS-SUS-16-035	2 SS l's	7: T1tttt[off], T5WW[off]...	ul	35.9	13
17	CMS-SUS-16-036	0L + jets + $\not{E}_T$	8: T1, T1bbbb, T1tttt[off]...	ul	35.9	13
18	CMS-SUS-16-037	1L + jets + $\not{E}_T$ with MJ	3: T1tttt[off], T5tt[off]tt...	ul	35.9	13
19	CMS-SUS-16-039	multi-l EWK searches	5: TChiChipmSlepL...	ul	35.9	13
20	CMS-SUS-16-041	multi-ls + jets + $\not{E}_T$	6: T1tttt[off], T6HHtt...	ul	35.9	13
21	CMS-SUS-16-042	1L + jets + $\not{E}_T$	2: T1tttt[off], T5WW[off]...	ul	35.9	13
22	CMS-SUS-16-043	EWK WH	1: TChiWH	ul	35.9	13
23	CMS-SUS-16-045	Sbottom to bHbH and H $\to \gamma\gamma$	2: T6bbHH, TChiWH...	ul	35.9	13
24	CMS-SUS-16-046	$\gamma + \not{E}_T$	2: T5gg, T6gg	ul	35.9	13
25	CMS-SUS-16-047	γ + HT	2: T5gg, T6gg	ul	35.9	13
26	CMS-SUS-16-049	All hadronic stop	4: T2cc, T2ttC, T2tt[off]...	ul	35.9	13
27	CMS-SUS-16-050	0L + top tag	4: T1tttt[off], T2tt[off]...	ul	35.9	13
28	CMS-SUS-16-051	1L stop	2: T2tt[off], T6bbWW...	ul	35.9	13
29	CMS-SUS-17-001	Stop search in dil + jets + $\not{E}_T$	2: T2tt[off], T6bbWW...	ul	35.9	13
30	CMS-EXO-12-026	hscp search	3: THSCPM1b, TRHadGM1...	ul	18.8	8
31	CMS-EXO-13-006	hscp search	8: THSCPM1b, THSCPM2b...	eff	18.8	8
32	CMS-PAS-SUS-12-022	multi-l + $\not{E}_T$	6: TChiChipmSlepL...	ul	9.2	8
33	CMS-PAS-SUS-12-026	>= 3 l's (+jets) + $\not{E}_T$	1: T1tttt	ul	9.2	8
34	CMS-PAS-SUS-13-015	>= 5(1b-)jets + $\not{E}_T$	1: T2tt[off]	eff	19.4	8
35	CMS-PAS-SUS-13-016	2 OS l's + >= 4 (2 b-)jets + $\not{E}_T$	1: T1tttt[off]	ul	19.7	8
	CMS-PAS-SUS-13-016	2 OS l's + >= 4 (2b-)jets + $\not{E}_T$	1: T1tttt[off]	eff	19.7	8
36	CMS-PAS-SUS-13-018	1-2 b-jets + $\not{E}_T$, M_CT	1: T2bb	ul	19.4	8
37	CMS-PAS-SUS-13-023	hadronic stop	2: T2tt[off], T6bbWW[off]...	ul	18.9	8
38	CMS-PAS-SUS-14-011	razor with b-jets	3: T1bbbb, T1tttt[off]...	ul	19.3	8
39	CMS-SUS-12-024	0 l's + >= 3 (1b-)jets + $\not{E}_T$	1: T1tttt[off]	ul	19.4	8
	CMS-SUS-12-024	0 l's + >= 3 (1b-)jets + $\not{E}_T$	2: T1bbbb, T1tttt[off]...	eff	19.4	8
40	CMS-SUS-12-028	jets + $\not{E}_T$, α_T	5: T1, T1bbbb, T1tttt...	ul	11.7	8
41	CMS-SUS-13-002	>= 3 l's (+jets) + $\not{E}_T$	1: T1tttt	ul	19.5	8
42	CMS-SUS-13-004	>= 1 b-jet + $\not{E}_T$, Razor	3: T1bbbb, T1tttt[off]...	ul	19.3	8
43	CMS-SUS-13-006	EW prod, to l's, W, Z, and H	5: TChiChipmSlepL...	ul	19.5	8
44	CMS-SUS-13-007	1 l + >= 2 b-jets + $\not{E}_T$	2: T1tttt[off], T5tttt...	ul	19.3	8
	CMS-SUS-13-007	1 l + >= 2 b-jets + $\not{E}_T$	1: T1tttt[off]	eff	19.3	8
45	CMS-SUS-13-011	1 l + >= 4 (1b-)jets + $\not{E}_T$	2: T2tt[off], T6bbWW[off]...	ul	19.5	8
	CMS-SUS-13-011	1 l + >= 4 (1b-)jets + $\not{E}_T$	1: T2tt[off]	eff	19.5	8
46	CMS-SUS-13-012	n_{jets} + HTmiss	3: T1, T1tttt[off]...	ul	19.5	8
	CMS-SUS-13-012	n_{jets} + HTmiss	19: T1, T1bbbb, T1btbt...	eff	19.5	8
47	CMS-SUS-13-013	2 SS l's + (b-)jets + $\not{E}_T$	2: T1tttt[off], T6ttWW[off]...	ul	19.5	8
	CMS-SUS-13-013	2 SS l's + (b-)jets + $\not{E}_T$	1: T1tttt[off]	eff	19.5	8
48	CMS-SUS-13-019	>= 2 jets + $\not{E}_T$, MT2	6: T1, T1bbbb, T1tttt[off]...	ul	19.5	8
49	CMS-SUS-14-010	b-jets + 4 Ws	1: T1tttt[off]	ul	19.5	8
50	CMS-SUS-14-021	soft l's, low n_{jets}, high $\not{E}_T$	1: T2bbWW[off]	ul	19.7	8

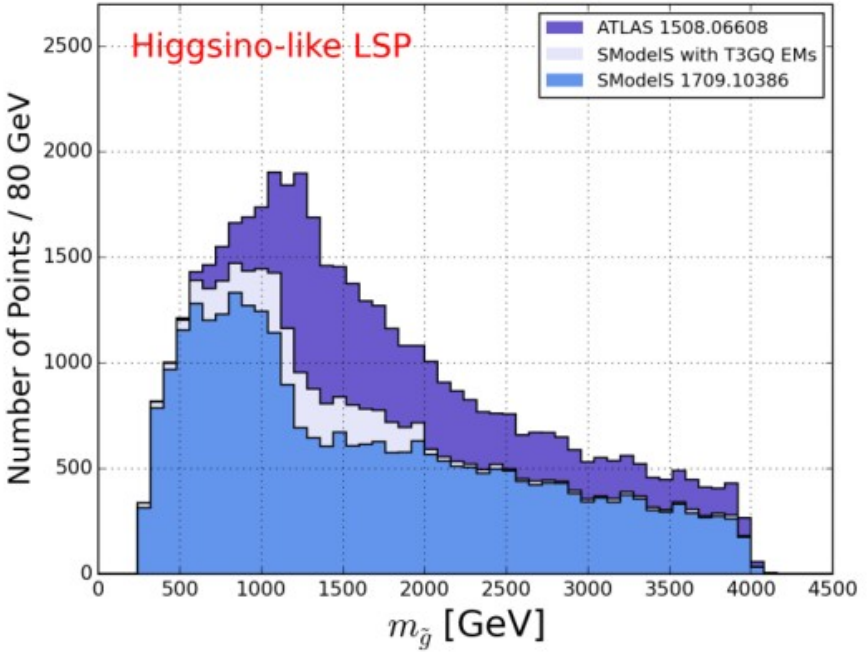
We collect the results of the experimental collaborations, and augment them with recast analyses (MadAnalysis5, CheckMATE), creating our own efficiency maps. In addition, fastlim kindly allowed us to also use their efficiency maps. SModelS v1.2.2 ships with results of almost 100 different analyses.

https://smodels.github.io/docs/ListOfAnalyses

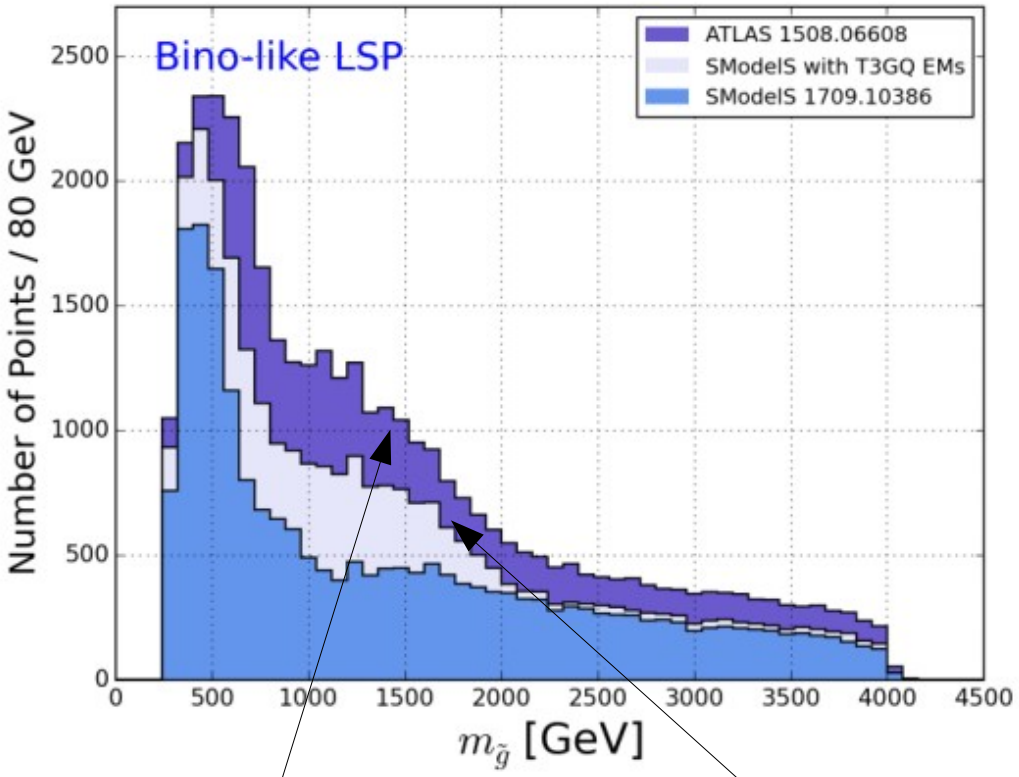
SModelS – trading in constraining power for speed

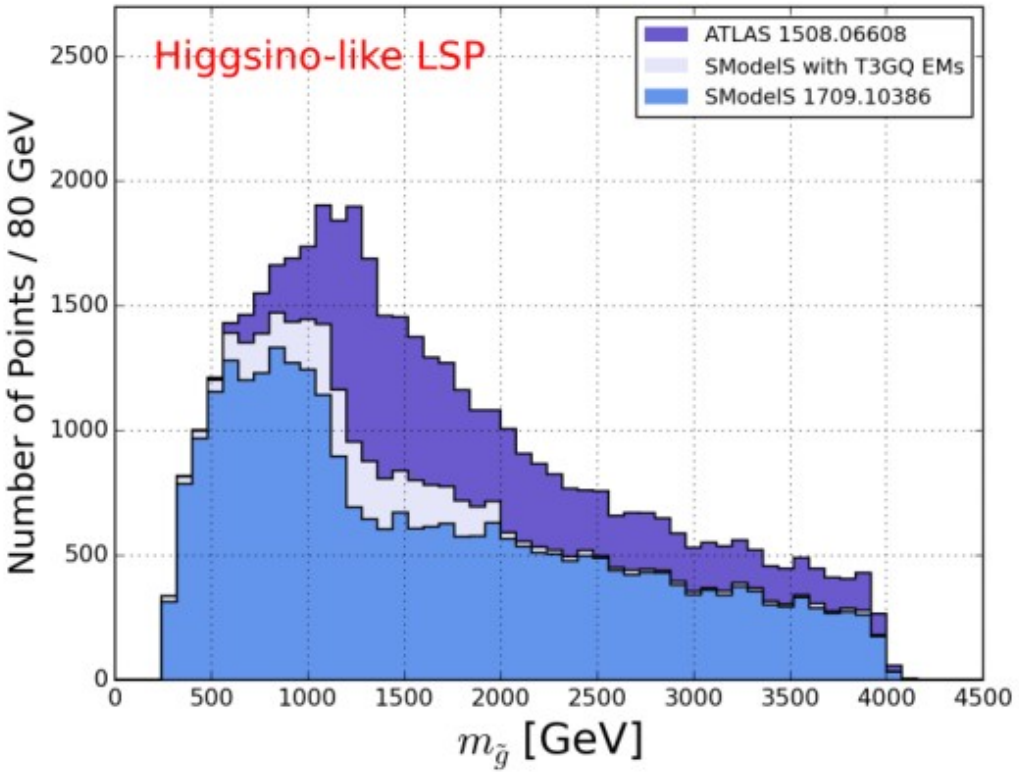
In comparison with recasting methods like MadAnalysis and CheckMATE, SModelS exclusions are more conservative, but much faster. A direct comparison with an ATLAS pMSSM scan [arXiv:1508.06608] gave us a clue as to how much more conservative we are, and which topologies we miss out on (i.e. the analyses are in principle sensitive to, but no interpretations for these topologies are published).





SModelS – trading in constraining power for speed





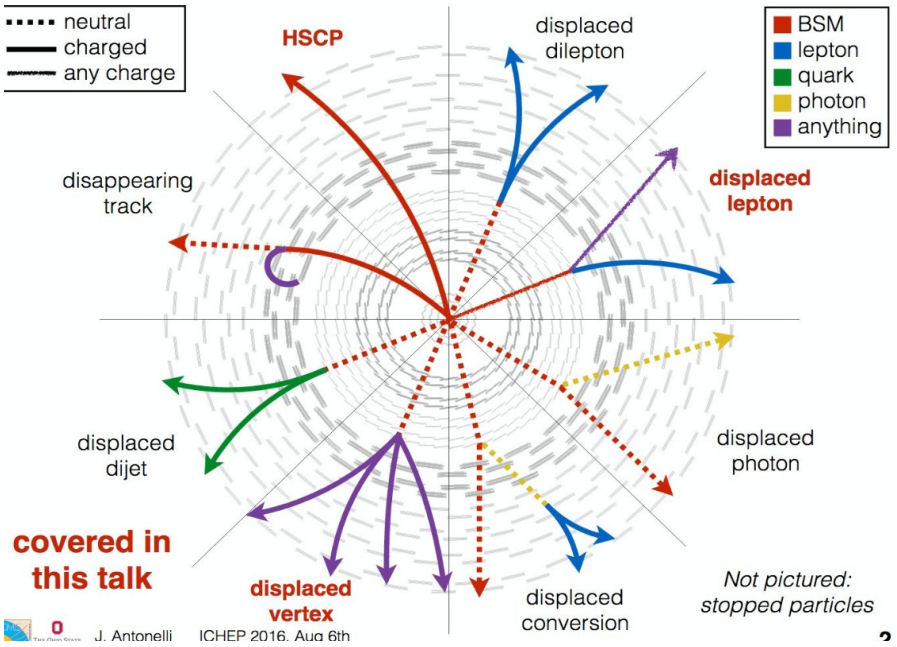
number of points that the ATLAS result could exclude

number of points our simplified models results of these ATLAS analyses exclude (**about 70 – 75%**)

Ongoing development:

SModelS v2.0: displaced signatures

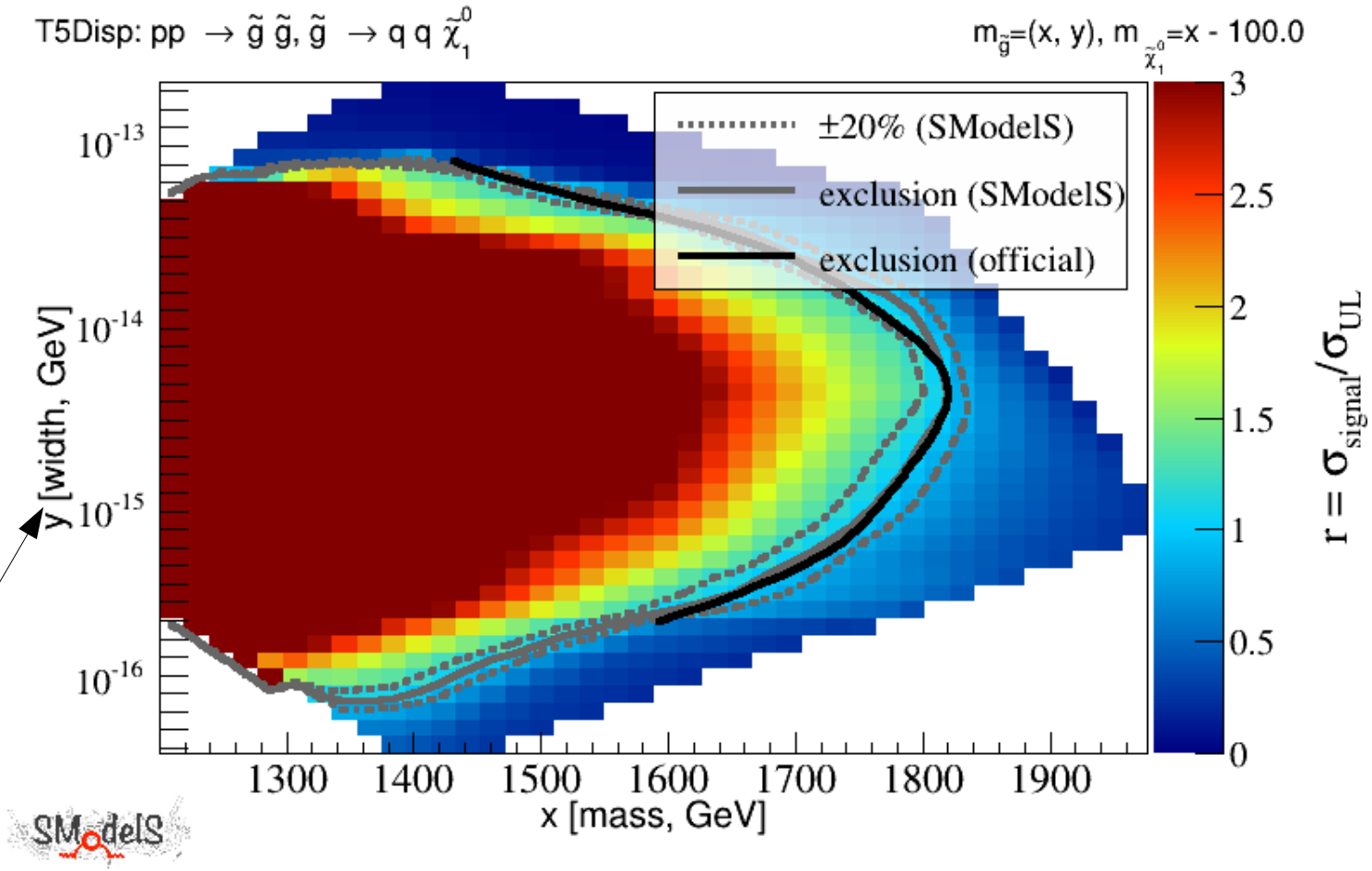
We are currently in the validating phase of v2.0. We expect to be able to release v2.0 by this summer. Largest improvement: treatment of all kinds of displaced signatures. We hope to release before this summer.



J. Antonelli

Technology preview:

SModelS v2.0: displaced signatures



First validation plot of an entry in the SModelS database, as a function of the **width** in addition to the mass of the BSM particle.

Longer term plans for SModelS ≥ v2.1

Our long term plans include:

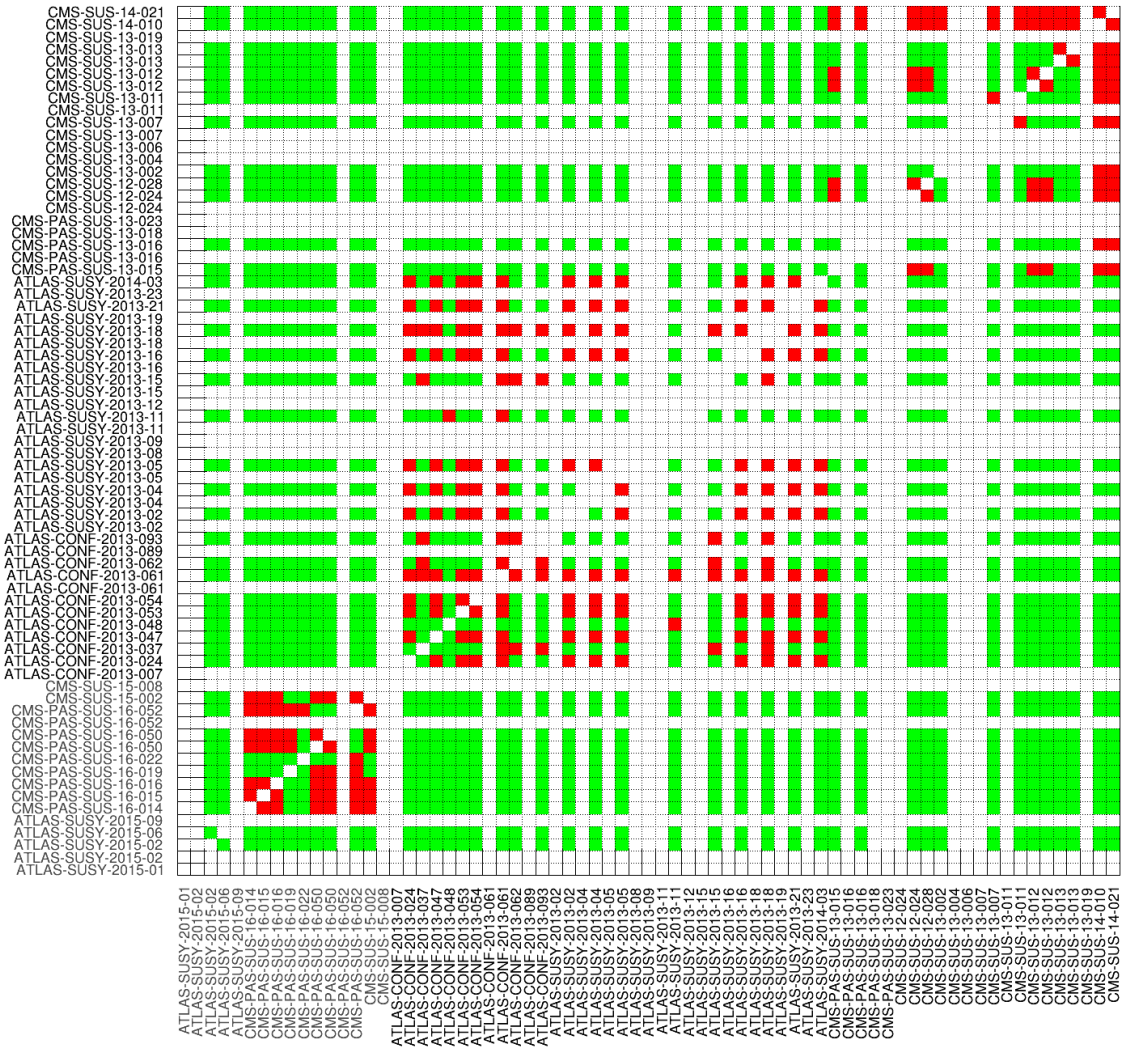
- **Extension of experimental symmetries beyond Z_2 symmetries: dark matter models, resonances, ….**
  Even in v2.0.x we will still be limited to models with Z_2 symmetries and two-branch structures (our SUSY legacy)
- Use simple **Multi-Layer Perceptrons** to speed up the lookup and interpolation of the experimental results
- allow also e.g. **UFO files** to describe the input model
- **Joint likelihoods for combining analyses**
  We can trace which analysis results are approximately uncorrelated, and which arent. Exploiting this information we can compute joint likelihoods for combinations of uncorrelated analyses. A combinatorial optimizer can find the best (expected) combination.
- **Description of positive results with simplified models**
  So far we are only treating exclusions – negative results

Combination of analyses

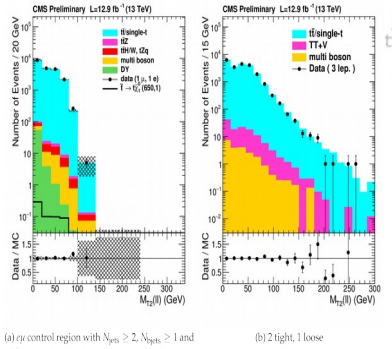
Joint likelihoods for combining analyses

many pairs of analyses can be treated as approximately uncorrelated (the green blocks, think e.g. of a 8 TeV ATLAS result and a 13 TeV CMS result)

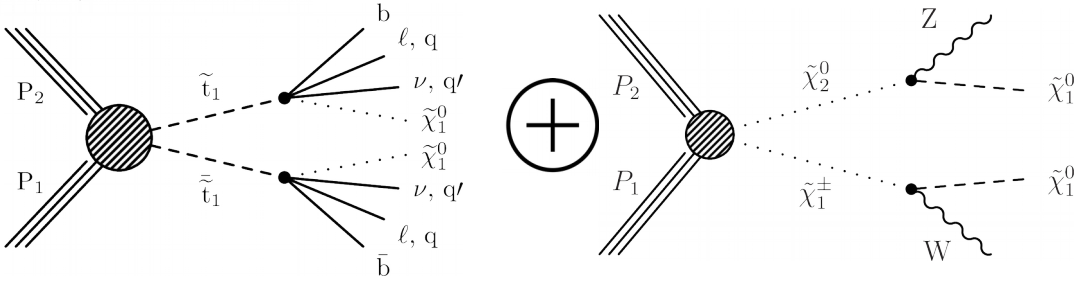
Correlations between analyses (green is uncorrelated)



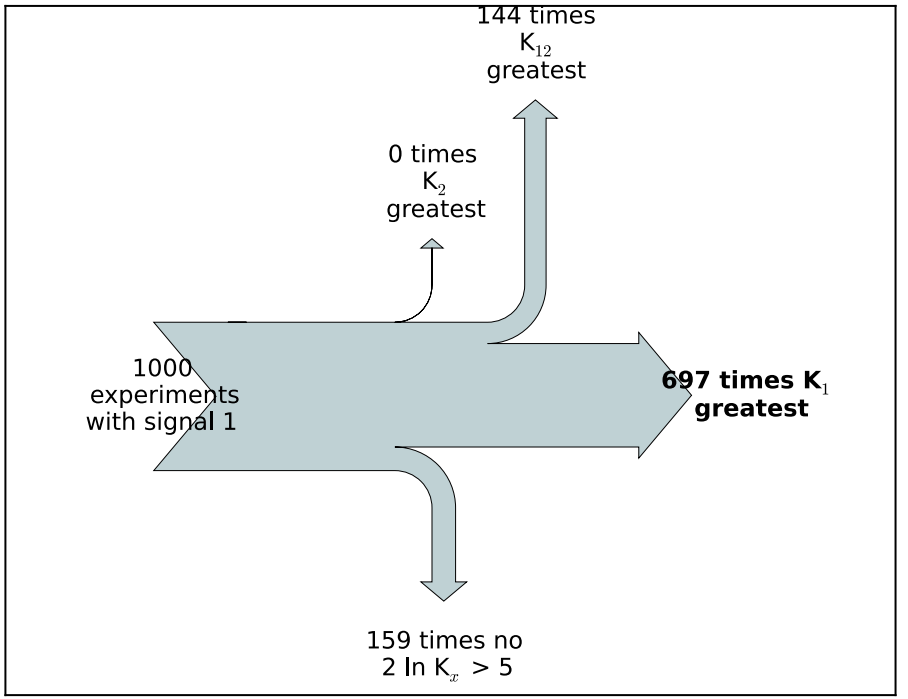
Description of positive results with simplified models



So far we are only treating exclusions – negative results. In the long run, we also want to be able to describe positive results with simplified models in SModelS. Positive results with simplified models are more tricky because the problem of model selection becomes non-trivial. We intend to solve model selection with Bayes factors, parameter inference with likelihood maximization.



Example on the right: mockup study, two candidate models (above), and the model selection outcome, when model #1 is "right".



http://smodels.github.io

pip3 install –user smodels

Thank you!